

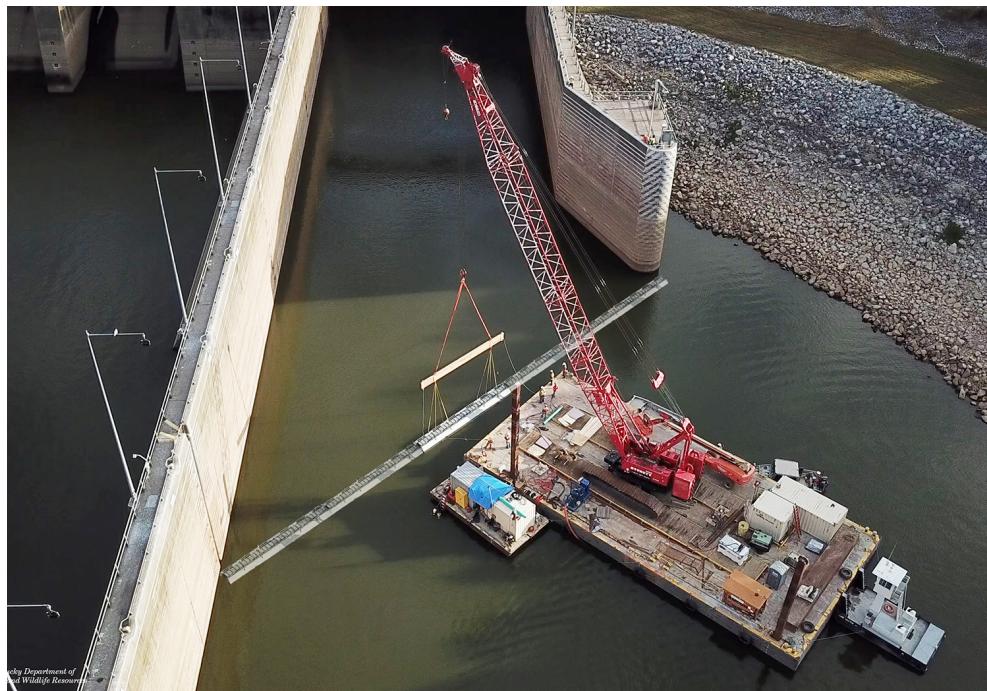
Lake Barkley BioAcoustic Fish Fence Effectiveness Study

Questions and Answers

Four species of non-native invasive carp—bighead, black, grass and silver—can be found within the waters of the United States. The surge of invasive carp threatens the country's renowned aquatic biodiversity, outdoor economies and way of life. Federal, state, university and industry partners have joined together to test a new and innovative fish deterrent technology to slow the carps' upstream push. A BioAcoustic Fish Fence, or BAFF, has been deployed on the downstream side of Barkley Lock in Kentucky to determine its effectiveness at reducing the movement of invasive carp through a lock chamber.



The air-bubble curtain, visible when the BAFF is turned on.



The BAFF, or BioAcoustic Fish Fence, being installed at Lake Barkley Lock and Dam.

What is a BioAcoustic Fish Fence, or BAFF? How does it work?

Developed by Fish Guidance Systems, the BAFF is designed to deter or guide fish using sound, strobe lights, and air bubbles. The BAFF in the downstream approach channel at Barkley Lock may deter invasive carp from using the lock to move into Lake Barkley.

A line of bubbles runs diagonally across the lock approach channel between the walls. Sound is projected within the air bubbles where it is amplified and trapped. Some sound and light may escape the water and be detected by boaters. At night, flashing white lights can be visible, especially when water levels are low.

The BAFF has the potential to deter the movement of fish without impeding navigation.

How long will the BAFF be in place?

Currently, the BAFF is scheduled for removal in fall 2023 and the study

will conclude after three years of data collection. The BAFF may remain in place longer to evaluate additional BAFF settings or to collect additional fish behavior data. If effective, partners may also pursue a permanent installation.

How effective is a BAFF at stopping invasive carp?

Tests conducted by the University of Minnesota found that a BAFF-like device was 97% effective at blocking bighead carp without habituation in a lab setting. The purpose of this project is to evaluate the BAFF's effectiveness in a field setting, which may differ.

Why isn't an electric dispersal barrier being used at Lake Barkley?

Electric dispersal barriers have been installed and tested in the Chicago Area Waterway System. This project is specifically designed to field test the BAFF as an alternative type of deterrent for deterring invasive carp passage through a lock chamber.

Why is fishing restricted around the BAFF?

Fishing and recreational boating are prohibited from the outer canal wall to the lock chamber to protect the BAFF and telemetry receivers from getting damaged by anglers or anchors. Restricted areas are clearly marked.

How is the BAFF effectiveness study funded?

The project is funded by the U.S. Environmental Protection Agency's Great Lakes Restoration Initiative, U.S. Fish and Wildlife Service and the U.S. Geological Survey.

Who is leading this project?

The U.S. Fish and Wildlife Service in collaboration with the U.S. Army Corps of Engineers, U.S. Geological Survey, Kentucky Department of Fish and Wildlife Resources, Tennessee Wildlife Resources Agency, University of Minnesota and others. Fish Guidance Systems is a technology partner.

How does the study track fish movement?

The study uses an HTI telemetry system to triangulate the positions of silver carp that were translocated below the BAFF to determine BAFF crossings with high precision. A second pre-existing VEMCO telemetry system was also used to determine the distribution of several fish species that were tagged and released at various capture locations and then tracked to determine BAFF crossing rates indirectly.

What effect will the BAFF have on the movement of other fish species?

The sounds emitted by the BAFF affect invasive carp because they are very sensitive to sound, particularly at certain frequencies. Many native fish species do not have this same sensitivity, but may be affected by the combination of sounds, lights and bubbles. This project will also study whether the BAFF influences the movements of native fish using the same approach of telemetry tagging and tracking. Lab studies indicate that while the BAFF does deter some native fish, they may be less affected than invasive carp.

Why is Barkley Lock and Dam an ideal test site for a BAFF?

Barkley lock approach offers a number of advantages. Invasive carp are present in the area and pass upstream through the lock. As a result, this project can study whether the BAFF will slow their rate of passage. Another advantage is that the only pathway for fish to get from below the dam into Lake Barkley is to pass through the lock.



Electro-fishing silver carp at the tailwaters of Lake Barkley Lock and Dam.

What else is being done to address invasive carp in the Tennessee and Cumberland systems?

State agencies, including Kentucky Department of Fish and Wildlife Resources and Tennessee Wildlife Resources Agency, along with U.S. Fish and Wildlife Service and U.S. Geological Survey are conducting multiple management and research projects in the Ohio, Tennessee and Cumberland rivers to inform decisions on control including deterrent placement and harvest for invasive carp.

As of spring 2021, commercial fishers have harvested more than twenty million pounds of invasive carp from Kentucky and Tennessee waters, including Lake Barkley and Kentucky Lake, as part of an incentives harvest program.

Partners are also evaluating experimental methods and equipment for increasing efficiencies of removing invasive carp from our waterways.

References

CE Dennis et al. 2019. A complex sound coupled with an air curtain blocks invasive carp passage without habituation in a laboratory flume. *Biological Invasions* 21:2837-2855.

CE Dennis & PW Sorensen. 2020. High-intensity light blocks bighead carp in a laboratory flume. *Management of Biological Invasions* 11:441-460.

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Lake Barkley BioAcoustic Fish Fence Effectiveness Study Project Status Update

January 2022

This preliminary information and data are deliberative and pre-decisional!

The first year of the three-year study has concluded. This study used a fine-scale HTI telemetry system to track translocated silver carp and a coarse-scale VEMCO telemetry system to track non-translocated fish. BAFF effectiveness is being assessed by determining BAFF crossings by fish during alternating on and off cycles. Upstream BAFF crossings were as follows:

Winter 2020-2021

Based on HTI telemetry of translocated fish, 57 silver carp crossed the BAFF when off and 4 crossed while on (14:1 ratio).

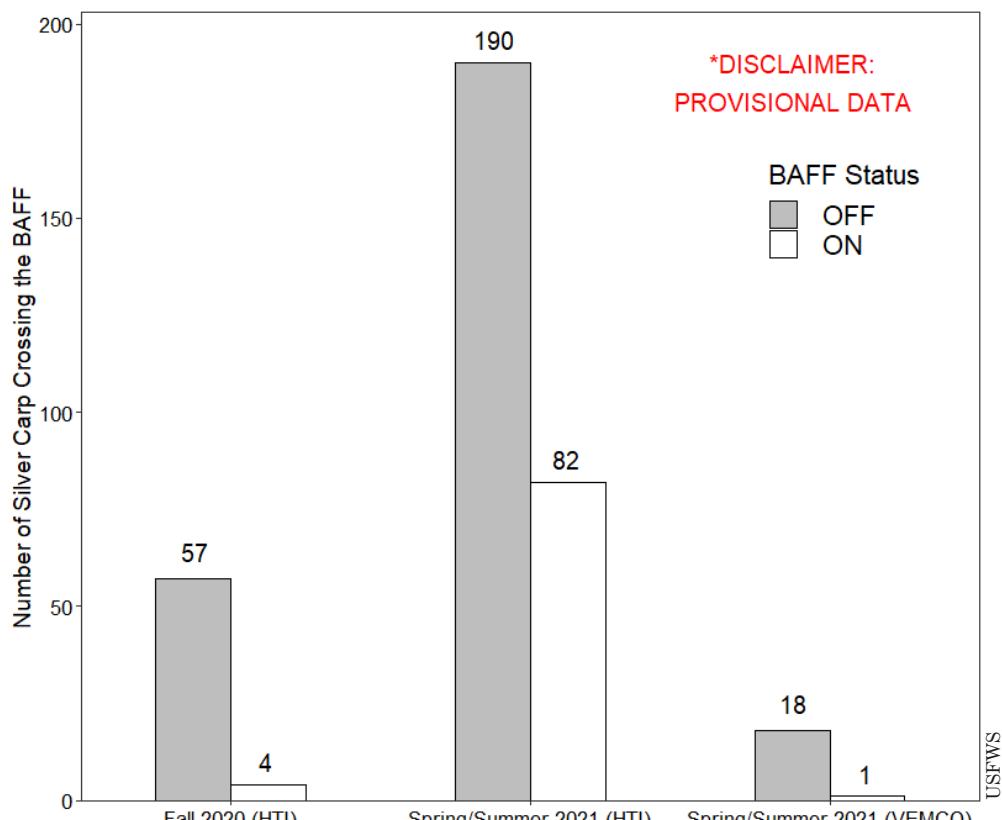
Spring/Summer 2021

Based on HTI telemetry of translocated fish, 190 silver carp crossed the BAFF when off and 82 crossed while on (2:1 ratio).

Based on VEMCO telemetry of non-translocated fish:

- 18 silver carp crossed the BAFF when off and 1 crossed while on (18:1 ratio).
- 7 freshwater drum crossed the BAFF when off and 2 crossed while on (4:1 ratio).
- 8 paddlefish crossed the BAFF when off and 7 crossed while on (1:1 ratio).
- 0 smallmouth buffalo crossed the BAFF when off and 1 crossed while on (0:1 ratio).

The data summarized here are a subset of the data that are being collected on the BAFF operation and the response of fish to the operation of the BAFF. Additional analyses of these data are ongoing and are expected to provide additional insights on where and when fish interacted with the BAFF, and



*DISCLAIMER:
PROVISIONAL DATA

BAFF Status
 OFF
 ON

Provisional data depicting silver carp crossings of the BAFF in off/on cycles during Fall 2020 (HTI only) and Spring/Summer 2021 (HTI and VEMCO).

*Disclaimer: Data are preliminary or provisional and are subject to revision. They are being provided to meet the need for timely best science. The data have not received final approval by the U.S. Geological Survey (USGS) and are provided on the condition that neither the USGS nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the data.

the environmental and navigation conditions that may have influenced that interaction. Accounting for environmental factors (temperature, water depth, lock operations, season, among others) may further our understanding of the behavioral response of fish and the BAFF's effectiveness.

Acoustic transmitters have been implanted in nearly 1100 silver carp and more than 225 in native fish to help inform this evaluation of the BAFF. Another 1500 transmitters will be implanted in silver carp and native fish to further this study. Tracking this large number of fish over the three-year

project period will provide unprecedented data on the movement of invasive carp and native fish around navigation dams and the BAFF that will inform this investigation and future understanding of how fish interact with navigation structures and behavioral deterrents. Data users are cautioned to consider carefully the provisional nature of the information before using it for decisions that involve substantial monetary or operational consequences.

